Lateral Coherence and Mixing in the Coastal Ocean: Adaptive Sampling using Gliders

R. Kipp Shearman
Jonathan D. Nash
James N. Moum
John A. Barth
College of Oceanic & Atmospheric Sciences
Oregon State University
Corvallis, OR 97331-5503
ph: (541) 737-1866 fx: (541) 737-2064 email: shearman@coas.oregonstate.edu

Award #: N00014-09-1-0379
http://gliderfs.coas.oregonstate.edu/gliderweb/

LONG-TERM GOALS

Lateral mixing is driven through the interplay between finescale isopycnal stirring (shear + strain) and small-scale diapycnal turbulence. We seek to understand this interplay within highly anisotropic coherent structures, such as fronts, jets, eddies and filaments, which likely control lateral dispersion in both coastal and open ocean. These structures evolve yet are often persistent on O (3 day) timescales, so are ideally suited to be adaptively sampled by autonomous gliders that actively report both turbulent and finescale statistics.

OBJECTIVES

As part of a coordinated effort to quantify the meso- through micro-scale processes driving lateral dispersion, we plan to deploy 4 AUV gliders to perform intensive, adaptive surveys. Newly-enhanced to measure turbulent mixing, water-column currents and dye concentration, these OSU autonomous gliders will capture the interplay between shear, strain, and turbulence over a wide range of scales. In conjunction with ship-based dye release experiments, adaptive glider sampling will substantially increase the synoptic coverage of the dye surveys, providing a more complete description of the spread and dispersion of the dye. Microstructure sensors will allow for the quantification of small-scale mixing and its dynamical feedback to meso and sub-mesoscale flows. ADCP imaging of water-column velocity will (i) characterize the features driving fluid dispersion, (ii) help build better turbulence parameterizations in anisotropic environments, and (iii) will provide enhanced tracking capabilities for lateral coherence calculations. The scarcity of synoptic observations in the past has made it impossible to detangle the lateral and vertical processes. Adaptive sampling with multiple gliders in multiple locations for extended durations will provide the detailed statistics necessary for the community to make progress.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2009**	2. REPORT TYPE	3. DATES COVERED **00-00-2009 to 00-00-2009**

4. TITLE AND SUBTITLE **Lateral Coherence and Mixing in the Coastal Ocean: Adaptive Sampling using Gliders**	5a. CONTRACT NUMBER
	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Oregon State University,College of Oceanic & Atmospheric Sciences,Corvallis,OR,97331-5503**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**3**	

APPROACH

We plan to deploy four newly-enhanced, autonomous gliders to measure the lateral coherence and evolution of dynamically significant properties. These properties include velocity (U), velocity shear (dU/dz), stratification (N2), temperature (T), salinity (S), temperature variance dissipation rate (χ), turbulence dissipation rate (ε), turbulence diffusivity (K_T), biological fluorescence, and, in cooperation with a dye release experiment, dye concentration.

OSU enhanced gliders are ideal sampling platforms for multiple reasons:

- Because they incorporate acoustic Doppler current profilers (ADCPs) with bottom-tracking capabilities, these gliders will be tracked while below the surface, permitting continuous spatial coherence computations on horizontal scales spanning O (10 m – 10 km). Gliders will also be equipped with a six component gyro package (3 linear and 3 rotational rate sensors) which will provide enhanced navigational capabilities at water depths where bottom-tracking is unavailable. All navigational data will be post-processed in a full LADCP-type inversion (i.e., Visbeck, 2002, Nash et al 2007) that utilizes all ADCP, gyro, and GPS data to provide both water-column velocity and vehicle location/speed.
- Because all data are logged and reported back on a regular basis, all data (including velocity and turbulence data) will be incorporated into the adaptive sampling that will be necessary to track laterally coherent features. This will be the first use of turbulence data for guidance of autonomous vehicles using adaptive sampling
- Because each enhanced glider possesses measurement capabilities similar to that obtained during a single shipboard microstructure operation (albeit slower), a fleet of 4 enhanced gliders operating independently will both (1) sample more mixing/dispersion “events” from a statistical perspective, and (2) provide simultaneous observations at multiple locations – necessary for coherence calculations. The strength of this measurement is in addressing the interactions between isopycnal stirring via measurement of lateral coherence of dynamically significant aspects of the flow field and diapycnal mixing via direct turbulence measurements.

WORK COMPLETED

Tests were conducted in June 2009 (internal pod) over Stonewall Bank on Oregon’s continental shelf with the two existing microstructure gliders. These were coordinated with Chameleon turbulence profiling.

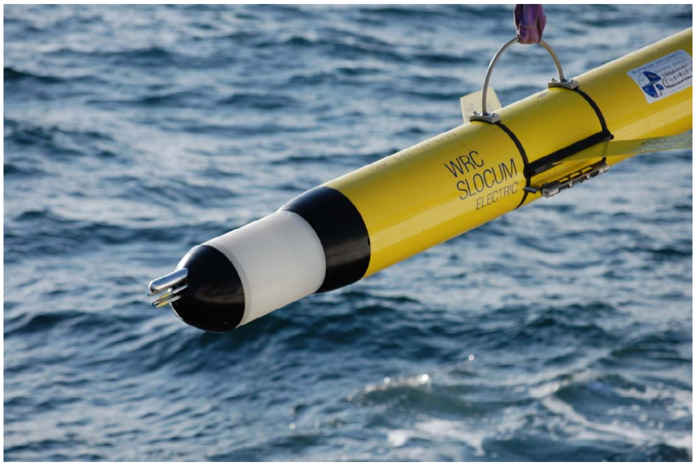

Figure 1 – Photograph of Webb glider with internal turbulence pod upon deployment in June 2009 over Stonewall Bank on Oregon’s continental shelf.

We have ordered two new Webb gliders, capable of diving to 350 m, to be outfitted with ADCPs and microstructure packages. The gliders are scheduled to be delivered in February 2010. In addition, we continue to plan the field work with our Lateral Mixing colleagues.

RESULTS

Since we are currently in the preparation and planning phase, there are no scientific results to report. From our previous testing and development work on the microstructure gliders however, we are analyzing the observations of cooling in the mixed layer under tropical storm Hannah (Wiles et al, 2009).

IMPACT/APPLICATIONS

Gliders offer a means of making two very valuable types of relatively autonomous measurements in the ocean. The first is the type of repeated routine observation that permits establishment of a climatology from which significant deviations can be identified and addressed. The second is the observation of extreme events (such as hurricanes) that cannot be made from ships. We have established standards of ocean turbulence measurements and have extended our ship-based vertical and horizontal profiling packages to moored mixing measurements. It has been a natural evolution to use this expertise to integrate new sensors into gliders that will both begin to define climatologies of mixing in coastal waters and lead to turbulence measurements in events such as hurricanes for which we have limited or no observation.

PUBLICATIONS

Wiles, P.J., J.N. Moum, S. Glenn, K. Shearman and J.D. Nash, 2009. Glider observations of pycnocline mixing over the Mid-Atlantic Bight induced by Tropical Storm Hanna, in draft form for *Geophys. Res. Lett.*